Modeling for Organizational Learning: Cognitive-maps and Agents Perspective

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Abstract

There is a growing tendency to consider organizational learning as a mechanism for improving organizations and the rate at which organizations learn becomes perceived as a source for attaining competitive advantage. The objective of this research is to present a two-phase(learning-efficient, and learning-effective) organizational modeling methodology based on the cognitive-maps and agents concept, and to describe how the result of the modeling can be used in the organizational learning context.

1. Introduction

Increasingly organizational learning is being considered as a mechanism for improving organizations [11] and the rate at which organizations learn becomes perceived as a source for attaining competitive advantage [5, 12, 13]. Although some recent research propose organizational learning and its involving change management as critical issues in information systems research [3, 4], there have been little research on the systematic modeling methodology for supporting organizational learning.

2. Conceptual Framework

In this section, we will discuss four elements which are relevant to our study: 1) modeling, 2) organizational learning, 3) cognitive-maps, and 4) agents.

2.1 Modeling

We can construct models in such a way as to highlight, or emphasize, certain critical features of a system, while simultaneously de-emphasizing other less important aspects of the system [14]. Therefore, there exists different highlighting point depending on the nature of modeling. Process modeling emphasizes on the process and data modeling focuses on the data, whereas cognitive modeling deals with interrelationships among cognitive concepts. Cognitive modeling has been given less attention by the analysts or the researchers than process or data modeling. However, as the importance of cause-effect relationships in an organizational context becomes increased, the interests about cognitive modeling become magnified. By modeling the cognitive aspects of organization, it is easy to capture the major interrelationships and patterns within organization.

2.2 Organizational Learning

Although organizational learning has been studied for a long time by numerous researchers, a clear definition of organizational learning seems to be elusive. Various researchers have suggested a variety of definitions for organizational learning. However, many researchers tend to view organizational learning as having two dimensions since Argyris and Schon classify it into single loop learning and double loop learning [1, 5, 9, 12]. For the purposes of our research, the dichotomy of organizational learning appears to be useful. As a consequence, we classify organizational learning into two dimensions: learning-efficient, and learning-effective. Learning-efficient involves the transfer of knowledge among members which may lead them to enhance organization's capacity efficiently, and emphasizes on the understanding of the existing organizational context which does not require significant organizational restructuring. Learning-effective involves the right usage of knowledge among members which may lead them to improve organization's capacity effectively, and focuses on the redesign of the existing organizational context which requires significant management innovation.

Although many research have proposed systems or guidances that support the process of organizational learning, most of them have emphasized on learning-efficient rather than learning-effective. As a consequence, the lack of learning-effective may keep an organization from being a learning organization which is skilled at creating, acquiring, and transferring knowledge, and at modifying its behavior to reflect new knowledge and insights [6]. Therefore, in this present research, we will present a two-phase organizational modeling methodology to support learning-efficient (which conforms to the existing organizational environment) as well as learning-effective (which involves the overall organizational redesign).

2.3 Cognitive-maps

Tolman first introduced the term cognitive-maps into the psychological literature in the 1940s [7], and after this, political scientist Axelrod used cognitive-maps in the 1970s for representing social scientific knowledge [2]. A cognitive-map is a representation of relationships that are perceived to exist among the attributes and/or concepts of a given environment [15]. Various researchers have named it differently depending on their context: cognitive-maps, cause maps, and influence diagrams. The constructs of cognitive-maps are nodes called causal concepts, and links representing causal connections among causal concepts. There are three kinds of cognitive-maps depending on the representation method of causal connections: simplest form which has either '+' or '-', weighted map which has a value in the interval [-1, 1], and fuzzy map which has fuzzy value such as 'more' or 'some' [10]. We will adopt a type of weighted map for the purposes of our research.

2.4 Agents

There have been many research on intelligent agents with a rich set of emerging views. Various researchers have devised different types of agents to describe and solve their problems. Depending on research objectives, each agent may behave differently or perform different tasks. This leads to classify intelligent agents according to some viewpoints. We suggest three categories for intelligent agents - HCI (Human-Computer Interaction) viewpoint which is concerned with relief of information and task overload through indirect management by intelligent agents, CDPS (Cooperative Distributed Problem Solving) viewpoint which is a problem solving through harmonious and dynamic interaction between distributed intelligent agents, and organization viewpoint which emphasizes on understanding of human organization and validation of organizational theory through intelligent agents concept. As the proliferation of artificial intelligence (AI) into other fields has given new opportunities in computer modeling of organization, AI is being broadly accepted as a tools for improving various modeling techniques. In essence, the study of intelligent agents presents an opportunity to integrate many significant results from the diverse research areas. In this research, we explore the possibility of applying the intelligent agents concept of organization viewpoint to an organizational issue - organizational learning.

3. Modeling for Organizational Learning: Cognitive-maps and Agents Perspective

In this research, the modeling for organizational learning consists of the following two phases: 1) modeling for learning-efficient, and 2) modeling for learning-effective.

3.1 Phase 1: learning-efficient

In this phase, we capture an individual agent's perception and understanding of an organization in cognitive-maps. This phase is addressed diagrammatically by using the constructs of cognitive-maps which consist of causal concepts, causal connections, and weighted causal values. We decided to call *our* cognitive-maps causal loop diagram because it involves the loops in the diagram. Through this phase, we get an overall understanding of organizational behavior which supports the sharing or transfer of knowledge, and based on this understanding we can improve learning-efficient. The result of this phase is used in phase 2 to aim at learning-effective.

3.1.1 Step 1: identify individual agents

In this research, we define agents as organizational units which can transfer or share their knowledge through communication. Agents, for example, can be departments or divisions, and their scale can be expanded to higher levels or reduced to lower levels depending on the level of analysis. It is important to capture the areas of high potentials whether they are problems or opportunities. If they are the potential threats, we will have to try to identify their causes and avoid them, while, if they are the potential opportunities, we will have to try to find the means for activating the opportunities. Clarifying the goal of each agent helps the analysts capture the cause-effect relationships. Because individual agents behave for attaining their goal, we can view the causal loop diagram as describing procedures for accomplishing their goal according to the cause-effect relationships.

3.1.2 Step 2: generate LCL diagram

This step generates local causal loop diagrams for the previously identified agents. Our causal loop diagrams allow of all kinds of concepts including state-based (ex., sales), action-based (ex., marketing activity) and emotion-based (ex., employee satisfaction) concepts. We should try to find the loops as many as possible. In the perspective of systems thinking, every influence can be both cause and effect, and thus an action may have consequences that come back to impact the action. Some techniques can be exploited to specify the causal values of each relationship. The subjective weights of analysts can be used, and the result of statistical analysis can be assigned to the relationships.

3.1.3 Step 3: generate GCL diagram

The objective of this step is to combine each LCL, and thus to generate global causal loop from them. The GCL plays a role as organizational memory. In order to combine LCLs, we first identify the common causal concepts between any two LCLs, and then link them using it. In turn, the next LCL is joined with the previous result. In this way, the combination process is continued until the remaining LCLs are exhausted. During the combination process, new concepts or new connections can be introduced into GCL, if necessary for describing the overall organizational behavior, and in that case, should be assigned appropriate causal values to them. During combining LCLs into GCL, various conflicts among LCLs can be occurred. These conflicts should be detected and resolved in order to create the complete GCL. Conflicts can be occurred in each construct of causal loop diagram. Conflicts and their resolution include the followings: 1) causal concept conflict and resolution, 2) causal connection conflict and resolution, and 3) causal value conflict and resolution. We use Kosko's fuzzy knowledge combination formula to resolve causal value conflicts because it is theoretically sound and rests entirely on uncertainty (fuzzy or random) intuitions which reflect well the cognitive model of organization [8]. It is also necessary to specify the goal of group agent. Clarifying the goal of group agent is helpful to understand the overall organizational behavior depending on the cause-effect relationships.

3.2 Phase 2: learning-effective

In phase 2, we extract the causal impact paths and values based on GCL diagram. This phase is addressed computationally by using the algorithm. In this phase, we identify the opportunities of organizational behavior reengineering, which lead to learning-effective.

3.2.1 Step 1: generate GCL matrix

In this step, we prepare for proceeding toward phase 2 which triggers learning-effective. We translate all information in GCL diagram to a form suitable for the analysis. In order to improve the convenience of analysis, we use a matrix representation method. It allows us to perform some computations, and provides updatability which is suitable for applying the algorithm. GCL diagram can be transformed into an equivalent matrix form called GCL matrix. It represents the direct causal impact between the causal concepts including the causal strength values of the relationships before the next step is completed.

Rows and columns of GCL matrix consist of all causal concepts in GCL diagram, and each row and column corresponds to a causal concept. Each cell entry of GCL matrix corresponds to a relationship between any two causal connections, and the value of the cell entry indicates the causal strength of the corresponding relationship. Causal concept *i*'s impact on causal concept *j* is represented in cell (i, j). In this way, we construct an $n \times n$ matrix with u_{ij} as a vale of cell (i, j) ,where n is the number of the causal concepts and u_{ij} is the causal strength value from causal concept i to causal concept j which lies in the interval [-1, 1].

3.2.2 Step 2: compute CIP/V

In this step, we compute causal impact paths and values based on the result of the previous step. The previous step deals with the direct causal impact paths and values which are given directly from the GCL diagram, while this step reveals the causal impact paths with the maximum causal impact values regardless of the direct impact or the indirect impact. These causal impact paths may take the negative values or the positive values or both depending on the causal impact values consisting of the feedback loops.

In order to compute the causal impact paths and values, we adopted the algorithms proposed by Zhang, et al. [15], and partially modified them to compute the paths and values simultaneously. At the end of step 2, we get an $n \times n$ GCL matrix consisting of X_{ij}, where X_{ij} is a set of $\{+p_{ij}, -p_{ij}, +v_{ij}, -v_{ij}\}$. Each element of the set is as follows: $+p_{ij}$ is a positive causal impact path from causal concept i to causal concept j, $-p_{ij}$ is a negative causal impact path from i to j, $+v_{ij}$ is a maximum positive causal impact value from i to j, and $-v_{ij}$ is a maximum negative causal impact value from i to j.

3.2.3 Step 3: analyze the result

The objective of this step is to analyze the causal impact paths and values, and thus to identify the chances of organizational behavior reengineering. These chances can occur at individual agents level or group agent level: 1) reengineering of individual agents' behavior, and 2) reengineering of group agent's behavior.

1. Reengineering of individual agents' behavior

From the result of the causal impact paths and values, we can identify the chances to modify individual agents' behavior depending on their perceptions. The causal impact paths may take both positive and negative impact value rather than take only positive impact value or only negative impact value because of the effect of the feedback loops. Therefore, we should consider both positive side and negative side in analyzing individual agent's behavior for accomplishing its goal. Because of the duality of the causal impact path, individual agents can modify or redesign their behavior according to a degree of risk acceptance. For two alternatives to accomplish the same goal, risk averter tends to select an alternative with less negative impact instead of more positive impact, while risk taker is inclined to take the opposite action.

2. Reengineering of group agent's behavior

We can also find the chances to modify group agent's behavior from the causal impact paths and values, and group agent's goal. This implies the overall redesign of the organizational behavior. In order to search for the chances of the redesign, we first focus on the most effective causal concept in achieving the goal regardless of the sign of the impact. It can be the opportunity when it is positive impact, and it can be the threat when it is negative impact. After this, we can redesign the relevant connections or feedback loops so as to make the positive impact stronger and the negative impact weaker.

The reengineering of organizational behavior can be performed in three ways. First, the reengineering can be conducted through the generation of new feedback loops. These also may be generated by adding new causal concepts or inserting new causal connections into the existing GCL. Second, the elimination of undesirable causal connections can bring us to the reengineering. Third, the elimination of unnecessary causal concepts also can lead to the reengineering.

4. Summary and Further Research

We proposed a methodology to generate a model for organizational learning based on the cognitive-maps and agents concepts. we classified organizational learning into two dimensions: learning-efficient, and learning-effective. Learning-efficient emphasizes on the understanding of the existing organizational context which does not require significant organizational restructuring, while learning-effective focuses on the redesign of the existing organizational context which requires significant management innovation. According to this dichotomy, we presented a two-phase organizational modeling methodology, and described how the result of the modeling can be used in the organizational learning context.

The proposed modeling is still at the conceptual level. As a consequence, the remaining task is to build a prototype system for supporting our modeling methodology and apply it to real world cases. The developed system will adopt GUI for ease of use and visualization. Another potential future direction of this research is to extend our modeling methodology into the areas of integrated modeling including process modeling and data modeling because the cognitive model can play a role as a complement for the other two modeling techniques.

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